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0439

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Build Strategy Development

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ABSTRACT

The 1985 NSRP "Design For Production Manual" (SP-4,1986) describes of a Build Strategy basis for improved shipbuilding performance through front end involvement of all departments and better COmmunication. A number of U.S. shipbuilders are known to have used the approach However, the extent of its use and the experience of the users was unknown.

To remedy this situation the SF-4 Panel conceived a project to determine;(l)how widely "the Build Strategy approach" was known and used by U.S. shipbuilders, and (2) a suitable Build Strategy framework with examples of its use for two typical ship types.

This paper summarizes the performance of the project and briefly describes the findings of the U.S. and foreign shipyard surveys and visits, the rquired prerequisites for use of a Build Strategy and benefits from its use. It also includes the contents list for the proposed Build Strategy framework

INTRODUCTION

All shipbuilders plan how they will build their ships. The plan may be only in someone's head or a detailed and documented process involving many people. Often different departments prepare independent plans which are then integrated by a "Master Plan/Schedule"..

A Build Strategy is much more than the normal planning and scheduling and a description of how the Production Department will build the ship.

Many shipbuilders use the term "Mild Strategy" for what is only their Production Plan. In terms of this project, this is incorrect. The term "Build Strategy" as used throughout this paper has a special specific meaning. It is also recognized that some shipbuilders have a process very similar to the Build Strategy approach but do not call it such

What is the meaning by the term Build Strategy for this project? Before specifying this, the aims of a Build Strategy are briefly discussed

It:

- applies a company's overall shipbuilding policy to a contract
- provides a kprocess for ensuring that deaign development takes full account of production requirements,
- systematically dmduces production engineering principles that reduce ship work content and cycle time,
- identifies interim products and creates product-oriented approach to engineering and planning of the ship,
- determines resource and skill retirements and overall facility loading,
- identifies shortfalls in capacity in terms of facilities, manpower and skills
- creates parameters for progmming and detail planning of engineering procurement and production activities
- provides the basis on which any eventual production of the product may be orgainzed including procurement dates for "long lead" material items.
- • ensures all departments contribute to the strategy,
- identifies and resolves problems before Work on the contract beings, and
- ensures Communication, cooperations, collaboration and consistency between the various technical and production functions.

In summary:

A BUILD STRATEGY IS AN AGREED DESIGN, ENGINEERING, MATERIAL MANAGEMENT, PR0DUCTION AND TESTING PLAN, PREPARED BEFORE WORK STARTS, WITH THE AIM OF IDENTIFYING AND INTEGRATING ALL NECESSARY PROCESSES.

BACKGROUND

It was A&P Appledore that conceived and developed the formal Build Strategy approach in the early 1970's. It developed from the ideas and processes generated to support the A&P Appledore associated "Ship Factories" at Sunderland and Appledore. The detailed work breakdown, formalized work sequencing and very short build cycles associated with these ship factories required the communication, coordination and cooperation that are inherent in the Build Strategy approach.

British Shipbuilders adopted the Build Strategy approach for all their shipyards (Vaughan, 1983)* and A&P Appledore consulting group continued to develop the approach as a service to their clients.

The Build Strategy approach was introduced into the U.S. by A&P Appledore's participation in IREAPS conferences, as well as through presentations to individual shipbuilders and the SP-4 Panel (Craggs, 1983; A&PA, 1983; and A&PA, 1984).

A&P Appledore consulting to NORSHIPCO, Lockheed Shipbuilding Company and Tacoma Boat introduced the use of the Build Strategy approach to U.S. shipbuilding projects. Finally, the Build Strategy approach was described in the DESIGN FOR PRODUCTION Manual, prepared by A&P Appledore for the SP-4 Panel (SP-4,1986).

The concept of the Build Strategy has existed for a number of years, and there has been an ongoing development of the concept in those shipyards which have adopted the Build Strategy approach. During this time, shipyards in Britain, and other countries, have had considerable experience in applying this technology, and it was appropriate to update the original Build Strategy approach in the light of this experience.

It is a known fact, but, unfortunately, a not an often practiced approach, that the performance of any endeavor will be improved by improvements in communications, cooperation and collaboration. A Build Strategy improves all three. It communicates the intended total shipbuilding project to all participants. This communication fosters improved cooperation as everyone is working to the same plan. It improves collaboration by involving most of the stakeholders (interested parties) in its development.

Why was this project necessary? It was perceived by some shipbuilders and the U.S. Navy that the formal documented Build Strategy approach had not been enthusiastically embraced by U.S. shipbuilders.

If the Build Strategy approach is thought to be such a good idea and/or shipbuilding improvement tool, it is surely worthwhile to try to find out if this is the case, and, also to find out why it is not being used by U.S. shipyards.

PREREQUISITES FOR A BUILD STRATEGY

A Build Strategy could be produced as a stand alone document for any ship to be built by a shipyard but it would be a great deal thicker and would take a lot more effort to produce if certain other documents had not been prepared earlier.

The first of these documents would be the shipyard's Business Plan, which will probably exist in most shipyards. A Business Plan sets out the shipyard's ambitions for a period of years and describes how the shipyard aims to attain them.

Next a Shipbuilding Policy should be in place. The policy defines the product mix which the shipyard intends to build plus the optimum organization and procedures which will allow it to produce ships efficiently. The Shipbuilding Policy will also include methods for breaking the ships in the product mix into standard interim products by applying a Product Work Breakdown Structure. Areas in which the interim products will be produced and the tools and procedures to be used will also be defined.

Ideally, a Ship Definition Policy will also exist. This specifies the format and content that the engineering information will take in order to support the manner in which the ships will be built.

If any of these documents do not exist, then the information relevant to a particular contract that would have been in them will have to be produced and included in the Build Strategy.

RELATIONSHIP BETWEEN SHIPBUILDING POLICY AND BUILD STRATEGY

A Shipbuilding Policy is the definition of the optimum organization and build methods required to produce the product mix contained within the company's shipbuilding ambitions, as defined in the Business Plan. The Shipbuilding Policy is aimed primarily at design rationalization and standardization, together with the related work organization, to simulate the effect of series construction. This is achieved by the application of group technology and a product work breakdown, which leads to the formation of interim product families.

* See REFERENCES

A Shipbuilding Policy is developed from a company's Business Plan, which usually covers a period of five years and includes such topics as:

- the product range which the shipyard aims to build,
- shipyard capacity and targeted output,
- targets for costs, and
- pricing policy.

The product range is identified, usually as a result of a market study.

The relationship between a Business Plan, Shipbuilding Policy, and Build Strategy is shown in Figure 1.

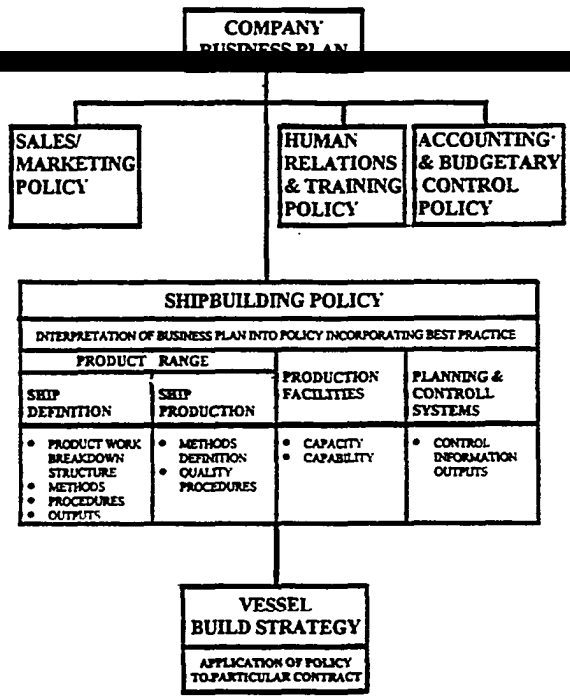

Figure 1 - Build Strategy and Shipbuilding Policy

The Business Plan sets a series of targets for the technical and production part of the organization. To meet these targets, a set of decisions is required on:

- facilities development,
- productivity targets,
- make, buy or subcontract, and
- technical and production organization.

These form the core of the Shipbuilding Policy. The next level in the hierarchy defines the set of strategies by which this policy is realized, namely the Build Strategy.

In essence, the Shipbuilding Policy comprises a set of standards, which can be applied to specific ship contracts. The standards apply at different levels:

- Strategic, related to type plans, planning units, interim product types, overall facility dimensions, and so on; applied at the Conceptual and Preliminary Design stages.
- Tactical, related to analysis of planning units, process analysis, standard products and practices, and so on; applied at the Contract and Transition Design stages.
- Detail, related to work station operations and accuracy tolerances; applied at the Detail Design stage.

Because shipbuilding is dynamic, there needs to be a constant program of product and process development. Also, the standards to be applied will change over time with product type, facilities, and technology development.

The shipbuilding policy is therefore consistent, but at the same time will undergo a structured process of change, in response to product development, new markets, facilities development, and other variations.

The policy has a hierarchy of levels which allow it to be applied in full at any time to a particular contract.

Therefore, to link the current policy with a future policy, there should be a series of projects for change which are incorporated into an overall action plan to improve productivity. Since facilities are a major element in the policy, a long term development plan should exist which looks to a future policy in that area. This will be developed against the background of future business objectives, expressed as a plan covering a number of years.

These concepts are summarized and illustrated in Tables I and II.

Work at the Strategic level provides inputs to:

- the conceptual and preliminary design stages,
- contract build strategy,
- facilities development,
- organizational changes, and
- the tactical level of shipbuilding policy.

At the strategic level, a set of documents would be prepared which address the preferred product range. For each vessel type, the documents will include:

- definition of the main planning units,
- development of type plans, showing the sequence of erection, and
- analysis of main interim product types.

TABLE 1
ELEMENTS OF SHIPBUILDING POLICY

POLICY OVERVIEW
Policy Based on Business Plan Objectives
Sets (objectives for Lower Levels

CURRENT PRACTICE
Existing Standards
"Last Best" Practice
Procedures to be Applied to Next Contract

PRODUCTIVITY ACTION PLAN
Covers Next Twelve Months
Plans Improvements in Specific Areas
Is a Set of Projects

FUTURE PRACTICE
Developed from Current Practice
Incorporates Outcome of Action Plan
Procedures to be Applied to Future Contracts

LONG TERM DEVELOPMENT PLAN
Covers Facilities Development
Covers a Five Year Period

TABLE 2
TYPICAL LIST OF CONTENTS IN A DETAILED SHIPBUILDING POLICY DOCUMENT

1.0 OVERVIEW
1.1 Objectives
1.2 Purpose and scope
1.3 Structure

2.0 PRODUCT RANGE
2.1 Product Definition
2.2 Outline Build Methods

3.0 OVERALL PHILOSOPHY
3.1 *Outline*
3.2 Planned Changes and Developments
3.3 Related Documents
3.4 *work Bsreakdown* Structure
3.5 coding
3.6 Technical Information
3.7 Workstations
3.8 standards
3.9 Accuracy Control

4.0 PHYSICAL RESOURCES
4.1 Outline
4.2 Planned Changes and Developments
4.3 Related Documents
4.4 Major Equipment
4.5 Steel Preparation and Subassembly
4.6 Outfit Manufacture
4.7 steel Assembly
$.8 outfit Assembly
4.9 Pre-Outfit Workstations
4.10 Berth/Dock Area
4.11 Engineering Department Resources

5.0 SHIP PRODUCTION METHODS
5.1 Outline
5.2 Planned Changes and Developments
5.3 Related Documents
5.4 Standard Interim Products, Build Methods,
5.5 Critical Dimensions and Tolerances
5.6 Steel Preparation
5.7 Steel Assembly
5.8 Hull Construction
5.9 Outfit Manufacture
5.10 Outfit Assembly
5.11 Outfit Installation
5.12 Painting
5.13 services
5.14 Productivity Targets
5.15 Subcontract Work

6.0 SHIP DEFINITION METHODS
6.1Outline
6.2 Planned Changes and Developments
6.3 Related Documents
6.4 Ship Definition Strategy
6.5 Pre-Tender Design
6.6 Post-Tender Design

7.0 PLANNING FRAMEEWORK
7.1 Outline
7.2 Planned Changes and Developments
7.3 Related Documents
7.4 Strategic Planning
7.5 Tactical Planning
7.6 Detail Planning
7.7 Performance Monitoring and Control

8.0 HUMAN RESOURCES
8.1Outline
8.2 Planned Changeds and Developments
B.3 Related Documents
8.4 Organization
8.5 Training
8.6 Safety

9.0 ACTION PLAN
9.1 Outline
9.2 Projects and Time scales

The strategic leve will also address the question of facility capability and Capacity.

Documentation on the above will provide input to the conceptual design stage course, in those cases where agent is undertaking the design work and the builder has not been identified.

Documentation providing input to the preliminary design stage will include:

- l preferred raw material dimensions,
- l maximum steel assembly dimensions,
- l maximum steel assembly weights,
- l material forming Capability, in terms of preferred hull configurations.
- l "standard" preferred outfit assembly sizes, configuration and weights, based on facility
- l capacity/capability, and
- l "standard" preferred service routes.

At the tactical level standard products and production practices related to the contract and transition design stages, and to the tactical planning level will be developed. All the planning units will be analyzed broken into a hierachy of products.

The policy documents will detine preterences with respect to:

- • standard interim products
- l standatd product processess and methods,
- • standartd production stages,
- l installation practices,
- l standartd material sizes, and
- l sandard piece parts.

The capacity and capability of the major shipyard facilities will also be documented

For the planning units, sub-networks will be developed which define standard times for all operations from installation back to preparation of production infomation. These provide input to the planning function.

At the Detail level, the policy provides standards for production operations and for detail design.

The documentation will include:

- **workstation descriptions.**
- **workstation capacity,**
- **workstation capability.**
- **design standards,**
- **accuracy control tolerances,**
- **welding standards, and**
- **testing requirements.**

Reference to the standards should be made in contracts, and relevant information made available to the design, planning and production funcitons.

As with all levels of the shipbuilding policy, the standartds are updated overtime, in line with product development and technological change.

A ship definition is a detailed description of the **procedures to be adopted, and the information and** format of that information to be produced by each department developing technical information within a shipyard. The description must ensure that the information produced by each department is in a form suitable for the users of that information.

These users include:

- shipownersortheiragen@
- shipyard management,
- classification societies
- government bodies,
- other technical departments
  - design and drawing offices,
  - CAD/CAM center,
  - lofting
  - planning

production engineering
production control,
material control,
estimating,
procurement, and
l production departments

Preferably the ship under consideration would also be of a type which has been identified in the Shipbuilding Policy as one which the shipyard is most Suited to build.

The next best scenario would be that the ship being designed was of a type for which a build strategy exists within the shipyard.

BENEFITS OF A BUILD STRATEGY TO U.S. SHIPBUILDERS

If mass production industries, such as automobile manufacturing are examined, there is no evidence of the use of build strategies.

Someshipyards, which have a very limited product Variety, in terms of interim and final products, generally speaking, also have no need for build strategies due to their familiarity with the products. If such shipyards, which are amongst the most productive in the world do not use build strategies, then why should the U.S. industry adopt the build strategy approach?

The answer lies in the differences in the commercial environments prevalent and the gearing of operating systems and technologies to the product mix and marketing strategies. In a general sense, the most prodcutive have identified market niches, developed suitable standard ship designs, standard interim products and standard build methods. By various means, these yards have been able to secure sufficient orders to sustain a skill base which has become familiar withvthose standards. As the degree of similarity in both interim and final products is high, there has been no need to re-examine each vessel to produce detailed build strategies, but many of them do as they find the benefitss greatly outweigh the effort.

It is most likely that the U.S. shipbuilding industry's **re-entry into major commercial international markets** will begin with one-offs or at best very limited series contracts. Furthermore, as many U.S. shipyards believe that it will be most effective to concentration complex vessels the build strategy approach will be a key factor in enabling the yards to obtain maximum benefit from the many advanced technologies, most of which have been made available through the work of the NSRP Ship Production Panels. Also, the Build Strategy approach will ensure that the way they are to reapplied is well planned and communicated to all involved.

Most shipyards will have elements of a Build Strategy Document in place. However, without a formalized Build Strategy Document the lines of communication may be too informal and variable for the most effective strategy to be developed.

A well organized shipyard will have designed its facilities around a specific product range and standard production methods which are supported by a variety of technical and administrative **developed according to the requirements of production,** and detailed in a Shipbuilding Policy. In this case, When new orders are received only work which is significantly different from any previously undertaken needs to reinvestigated in depth in order to identify possible difficulties.

Where it has not been possible to minimize product Variety, such investigations will become crucial to the effective operation of the shipyard. The outcome of these investigations is the Build Strategy Document.

A Build Strategy is a unique planning tool. By integrating a variety of elements together, it provides a **holistic beginning to end perspective for the project** development schedule. It is also an effective way of capturing the combined design and shipbuilding knowledge and proceses, so they can be continuously **improved, updated, and used as training tools.**

A Build Strategy effectively concentrates traditional meetings that bring all groups involved together evaluate and decide on how the ship will redesigned, **procured, constructed, and tested before any tasks are commenced or any information is "passed on."**

The objectives of the Build Strategy Document are as follows:

- l To identify the new vessel.
- l To identify the design and features of the new **vessel.**
- l To identify contractual and management targets.
- l To identify departures from the shipyard's shipbuilding Policy.
- l To identify constraints based on the new vessel being designed/constructed particularly with reference to other work underway or envisaged.
- l To idenlify what must be done to overcome the above constraints.

The last objective is particularly important as decisions taken in one department will have

implications for many Others. This means that effective interdepartmental communication is vital.

The very act of developing a Build Strategy will have benefits due to the fact that it requires the various departments involved to communicate and to think rationally about how and where the work for a particular contract will be performed. It will also highlight any potential problems and enable them to be addressed well before the "traditional" time when they will arise.

If a Shipbuildng Policy exists for the company, then it should be examined in order to ascertain if a ship of the type under consideration is included in the preferred product mix. If such a ship type exists then certain items will already have been addressed.

These items include:

- l outline build methods
- l work breakdown structure,
- coding,
- l workstations,
- l standard interim products,
- l accuracy control,
- l ship definition methods,
- l planning framework,
- l physical resources atshipyard,and
- .human resources.

One thing which is unique to any new ship order is how it fits in with the ongoing work in the shipyard. The Current work schedule must be examined in order to fit the ship under consideration into this schedule. key dates, such as cutting steel,keel laying,launch and delivery will thus be determined.

Using the keydates other events can be planned. These events are:

- l key event program,
- l resource utilisation,
- • material and equipment delivery schedule,
- l material and equipment ordering schedule,
- l drawing schedule,
- l schedule of tests and trials, and
- l stage payment schedule and projected cash flow.

Once the major events and schedules are determined they can be examined in detail to expand the information into a complete build strategy. For example,the event program can be associated with the work breakdown to produce planning Units and master schedules for hull, blocks, zones, equipment units, and systems.

The Build strategy Document should beused by all of the department listed above, aud a formal method of feedback of problems and/or proposed changes must be in place so that agreed procedures cannot be changed without the knowledge of the responsible person. Any such changes must then be passed on to all holders of controllcd copies of the build Strategy.

The Build Strategy is used to facilitate and strengthen the communication links. It should bring Up front and be used to resolve,potenlial conflicts between departments in areas of design details, if a manufacturing process,make by desicions and in the delivery goals.

ABuild Strategy can be usd as an effective people empowerment tool giving Participants the opportunity to workout all their needs together in advance Of performing the tasks.

The intent of a Build Strategy is to disseminate the information it containg to all who can benefit from knowing it. Throughout this report it is described as a hard copy document but today it could well be electronically stored and disseminated through local area network stations.

Producing a Build Strategy Document will not guarantee an improvement in productivity, although, as stated earlier, the process of producin the document will have many benefits. Full benifits will only be gained if the strategy is implemented and adheredto.

Positive effects of the Build Strategy approach are two-fold

- . During production managers and foremen have a guidance document which ensures that they are fully aware of the construction plan and targets,even those relating to other departments. This reduces the likehood of individuals making decisions which have adverse effects in other departments. Although often quoted by shipyards as being the reason for a Build Strategy, the benefits accruing from this are not *major*.
- l Prior to production, the use of the Build Strategy approach ensures that the best possible overall design and production philosophy is adopted crucial Communication between relevant departments is instigated early enough to have a significant influence on final costs. It is therefore the structured, cross-discipline philosophy which provides the down stream reductions in costs, and this is the major benefit

A yard which develops a strategy by this method will gain all the advantages whether or not a single

Build Strategy Document is produced. However, the imposition of the requirement for a single document should ensure that the development of the strategy follows a structured approach.

Perhaps the single most beneficial aspect of a Build Strategy is, that by preparing one, the different departments have to talk to each other as a team at the right time. A Build Strategy is a "seamless" document. It crosses all traditional department boundaries. It is an important step in the direction of the seamless enterprise. The most evident benefit is improved communication brought about by engaging the whole company in discussions about project goals and the best way to achieve them. It eliminates process/rework problems due to downstream sequential hand-over of tasks from one department to another by defining concurrently how the ship will be designed and constructed.

Some of the advantages mentioned by users of the Build Strategy approach are:

- helps prioritize work,
- serves as an effective team building tool,
- requires that people share their viewpoints because they need to reach a consensus,
- places engineers face to face with the customers - purchasing, production, test, etc.,
- expands peoples view of the product (ship) to include such aspects as maintenance, customer training, support service, etc.,
- fosters strong lateral communication,
- saves time through concentration on parallel versus sequential effort,
- facilitates resolution of differences and misunderstandings much earlier,
- greatly improves commitment ("buy in") by participants and the effectiveness of the hand-over later,
- serves as a road map that everyone can see and reference as to what is happening,
- facilitates coordinated communication, and
- develops a strong commitment to the process and successful completion of the project.

There are a few disadvantages mentioned by users, such as:

- effort and time to prepare the formal Build Strategy document,
- total build cycle appears longer to some participants due to their earlier than normal involvement,
- cross functional management is not the norm and most people currently lack the skills to make it work,
- experts who used to make independent decisions may have difficulty sharing these decisions with others in developing the Build Strategy, and
- a Build Strategy describes the complete technology utilized by a shipyard and if given to a competitor, it could negate any competitive advantage.

However, the users felt that the advantages greatly outweigh the disadvantages.

PERFORMANCE OF THE PROJECT

Although it was known that a number of U.S. shipbuilders have utilized Build Strategies, it was not known how many and how effective they were.

A number of shipyards and the U.S. Navy believed in the benefit of the Build Strategy approach and this project was undertaken to accomplish the following objectives:

- To determine, for a number of U.S. shipyards involved in building the selected ship types, capabilities and limitations, and to classify them into common U.S. industry criteria.
- To determine how many U.S. shipbuilders currently use formal documented Build Strategies.
- To familiarize U.S. shipbuilding personnel with the Build Strategy approach, requirements, and benefits.
- To determine U.S. shipyard perceived need for a formal Build Strategy.
- To prepare a generic Build Strategy that can be used by U.S. Navy program office during concept, preliminary, and contract design, as well as U.S. shipyards, as the basis for the Build Strategy for a specific project.
- To prepare specific examples of the use of the generic Build Strategy for two selected ship types.
- To provide a final report on the findings of the shipyard survey on the use of formal Build Strategies, the perceived requirements, shipyard capabilities and limitations and how they were used/incorporated into the generic Build Strategy.

SELECTION OF SHIP TYPES

Four ship types were offered as potential examples to the Panel Project Team, namely;

- Destroyer,
- Fleet Oiler,
- RO RO, and
- Container.

The Team selected the fleet oiler and the container ship in January 1993. As the project developed and the industry interest shifted even more from military to commercial ships, a number of sources recommended that the fleet oiler example be changed to a products tanker. Therefore, the final examples that were selected to demonstrate the use of the Build Strategy Development framework were a 42,400 tonne DWT Product Tanker and a 30,700 tonne DWT Container/RO RO ship.

Attempts to get ship design information from U.S. sources, for ships of these types recently designed and/or constructed, were unsuccessful. Therefore, an A&P Appledore design for a products tanker and the MarAd PD-337 Commercial Cargo Ship (non-enhanced) design were used for the examples.

QUESTIONNAIRES

BUILD STRATEGY and SHIPYARD CAPABILITIES AND LIMITATIONS questionnaires were prepared for distribution to U.S. and Canadian shipbuilders. Their purpose was to determine current understanding and use of the Build Strategy approach and to determine current capabilities and limitations regarding building of selected ship types so that "common capabilities and limitations" could be developed and used in the two Build Strategy examples.

Both questionnaires were sent to 22 private and Navy shipyards. Questionnaires were received back from three shipyards. The Build Strategy Questionnaire was completely filled out in all three cases. The Shipyard Capability and Limitation Questionnaire was only completely filled out by one shipyard, with the other shipyards completing from 30 to 50 percent. Only one of the shipyards that responded to the questionnaires was willing to meet with the project team. Two other shipyards agreed to a team visit during telephone calls to solicit support for the project. The Build Strategy Questionnaires were also completed for two shipyards that were visited but had not completed the questionnaires.

All five shipyards responding to the Build Strategy Questionnaire were familiar with the Build Strategy approach. Only one had never prepared a Build Strategy document, although even that shipyard did prepare many of the listed content components and was of the opinion that it was not worth the effort to produce a single Build Strategy document.

There were wide differences in the need for many of the listed content components to be in the Build Strategy document. However, 18 out of 51 components were identified by at least four shipyards, and another 11 components by at least three shipyards. These 29 components were identified as Build Strategy "recommended" components. Two components in the Construction Data group, namely: Number of Plate Parts and Number of Shape Parts, were considered unnecessary by all five shipyards. They will not be included in the Build Strategy Document. The remaining 20 components were identified as "optional".

The lack of response made it impossible to determine common capabilities and limitations. However, the following findings are presented:

- Two shipyards have existing Marketing Departments which are involved in Market Research. Interestingly, they both have only been involved in Navy or government contracts during the past decade.
- One shipyard has a central planning and scheduling department, the others have a Master Planning Group that integrates the planning and scheduling of the various departments.
- Two shipyards have separate Material Planning/Control Groups and all three shipyards that responded to the questionnaire use material coding MRP II or similar systems.
- Only one shipyard has a complete in house engineering capability. Both the other shipyards subcontract most of their engineering to marine design agents.
- Two shipyards use CAD concurrent engineering, production oriented drawings, standard engineering procedures and engineering standard details.
- All three shipyards have complete in-house lofting capability that are part of the engineering department.
- Two shipyards have Manufacturing Industrial Engineering groups that are part of the Production Department.

- Engineering in all three shipyards is functionally organized into the traditional hull, machinery and electrical although their work is prepared for block construction and zone outfitting.
- Two shipyards use self-elevating, self-propelled transporters up to 250 ton capacity, and both self and non-elevating trailers from 50 to 80 ton capacity. Fork lift trucks from 1 to 14 ton capacity are used for general material handling.
- All three shipyards claim to use block construction, zone outfitting and packaged machinery units. They all claim to use Accuracy Control for structure and one shipyard uses it for piping, ventilation and electrical components.
- All three shipyards have state of the art painting capabilities.

U.S. SHIPYARD VISITATION

The project team visited BethShip, Avondale Shipyards and NASSCO. Each visit lasted a minimum of four hours with one taking six hours. A proposed agenda was sent to each shipyard prior to the meetings, along with a number of additional questions which would be asked during the visit. The project team first presented background information on the project, such as description, objectives, and approach. Then the purpose of the meeting was presented, which was to discuss face to face the questionnaire responses and clarify any questions. It was also to see what each shipyard had done, and was doing, with regard to Build Strategy. In addition, the Shipbuilding Technology Office of the Naval Surface Warfare Center at Carderock, Maryland was visited. The purpose of this visit was to learn about the Generic Build Strategy activity being worked on for the Mid Term Fast Sealift Ship (MTFSS) program. The purpose of the meeting was to determine how the two projects could and should interact. The Navy reported that there was considerable confusion in the industry because of identical project titles, and concern regarding the relationship of the SP-4 Panel Build Strategy project and the U.S. Navy's Mid Term Fast Sealift Ship program. Questions being asked ranged from "Are they connected?" to "How are the two projects going to be differentiated?" There is no contractual connection. The MTFSS program is interested in using the Build Strategy approach for one specific ship in a number of shipyards to reduce the time taken from contract award to delivery of the ship. The SP-4 project is interested in showing many shipyards how to use the Build Strategy approach for any ship type. The visit was most beneficial in determining this difference and resulted in agreement that it was necessary to differentiate between the two projects to the maximum extent possible. It was mutually decided to rename the SP-4 project and further, to concentrating entirely on commercial shipbuilding and ship types. It was decided to clearly differentiate between the two projects by changing the title of the SP-4 project to BUILD STRATEGY DEVELOPMENT.

All shipyards and the Shipbuilding Technology Office were very cooperative and generous in the giving of their time and sharing of their experiences and information.

All three shipyards were familiar with the Build Strategy approach and had prepared a number of Build Strategies in preparation of bids. Ship types involved were container ship and product tanker. Two had used Build Strategies for at least one complete design/build cycle. Ship types involved were container, sealift conversion and T-AGS.

The departments having the major responsibility for the Build Strategy Development were under Production in two shipyards and part of Advanced Product Planning and Marketing in the other shipyard.

All three shipyards were committed to using the Build Strategy approach in continuing greater scope. This was entirely based on their own perceived needs/benefits and was not being driven by external demands or pressure.

The project team was able to review recent Build Strategies at each shipyard and was impressed by the level at which they were being used. Build Strategy size ranged from 100 to 300 pages. Typical effort ranged from 400 to 2000 man hours. However, it was pointed out that most of the effort would be required in any case. It simply was being performed earlier, up front, in a formal and concurrent manner. Based on this, the additional effort to prepare a Build Strategy is likely to be about 400 hours. Obviously, the first time it is done, the additional effort may be considerably more as the new approach must be learned in a team environment and many traditional barriers broken down.

By this review and discussion of the Build Strategies, it was possible to determine the items which were considered by the shipyards to be essential, which items were optional, and what should not be included in the Build Strategy document.

The project team emphasized that it was necessary for each shipyard to have a documented Shipbuilding Policy on which to base their Build Strategies.

Otherwise, each Build Strategy must contain the required policy components.

The shipyards had a number of concerns and emphasized the following requirements:

- Build Strategy document should not be so structured that it discourage innovation or the introduction of improved methods or facilities.
- It should not attempt to tell shipyards how to prepare drawings, build ships, define or limit block size or dictate required production information.
- It should incorporate need for design for producibility and be a guide for continuous improvement and TQM.
- The Build Strategy document and examples of its use should be based entirely on commercial ships of the type likely to be built in the U.S. in the foreseeable future.
- It should not address military ships of any type.
- The Build Strategy document must treat all components of the design, build, and test process with equal attention. So often the "simpler" or "better known" front end design and production decisions are more than adequately treated, but the back end processes, such as system tests and compartment check off, are given minimum consideration in a Build Strategy.
- The two examples of the Build Strategy document use should emphasize the ship type major differences and their impact on the Build Strategies.
- The project should emphasize the benefits of the formal Build Strategy approach. In doing this an attempt should be made to determine which world class shipbuilders use the Build Strategy or similar approaches.
- The project should also clearly describe the pre-requisites that a shipyard should have or develop before undertaking a Build Strategy to ensure the best chance of an effective Build Strategy being developed and implemented.
- The use of preliminary and detailed Build Strategies should be clearly described.
- The project should provide documentation that is suitable for use as an educational tool.

Because of the reluctance of most shipyards that were contacted to share the detailed information requested by the Shipyard Capabilities and Limitations Questionnaire, no renewed attempt was made to obtain this information during the visit. Instead, each shipyard visited was asked what were their two or three major limitations. All three shipyards mentioned crane capacity. They would all like to erect larger blocks than currently possible. One shipyard would like to increase crane capacity throughout the fabrication and assembly shops, as well as for block erection on the ways or in the dock. Another shipyard would like to have more covered (out of the weather) buildings for assembly and block construction. Finally, one shipyard mentioned that its major limitation was timely engineering.

U.S. SHIPYARD COMMON ATTRIBUTES

As previously mentioned, due to lack of response to the Shipyard Capabilities and Limitations Questionnaire, it was not possible to determine U.S. shipyard common attributes which could be used in the Build Strategy Document. In order to have a basis on which to prepare the project Build Strategy Document and examples of its use, a hypothetical shipyard was defined by the project team. The hypothetical shipyard represents no existing U.S. shipyard but rather attempts to reflect some of the facilities and capabilities of a typical U.S. shipyard that would be interested in competing in the world commercial ship market. It does not reflect the lowest common capabilities.

FOREIGN SHIPYARD VISITATION

Eight foreign shipyards were contacted, but only four responded and three of them agreed to a visit.

Visits to the three foreign shipyards were made in June and July, 1993. The shipyards were Ferguson's in Port Glasgow, Scotland, a successful small shipbuilder; Odense Steel Shipyard in Denmark, a successful large shipbuilder reputed to be one of the best shipbuilders in the world today; and Astilleros Espanoles in Spain, another successful large shipbuilding group which has utilized many of the NSRP project publications to assist them in their improvement program

All shipyards visited gave outstanding support in time and effort to the team, and their hospitality was exceptional. They were most open in showing and describing their facilities, processes, goals, and problems, and all stated that their willingness to participate in projects to help the U.S. shipbuilding industry improve was based on the belief that everyone benefits from an open exchange of technology, a sharing of problems, and the development of solutions for their resolution.

Ferguson's does prepare a Build Strategy for each contract. They cover most of the recommended items in the study proposed Build Strategy Document List. Most of the optional items are omitted, although they do include budgets. Build Strategy with budgets are given restricted distribution. The Production Engineering Group has the responsibility to prepare the Build Strategies with input from other groups/departments.

Ferguson's Build Strategy is relatively simple (that's how they like it), but even with their small size they still see and achieve benefits from using the Build Strategy approach. Ferguson's uses previous Build Strategies as the basis for new Build Strategy.

Ferguson's approach was to accept mid-1980 facilities and to concentrate on using their people more effectively through integrated processes.

Odense Steel Shipyard (OSS) has excellent facilities with up to date equipment and processes. They have an extensive ongoing facilities improvement program. They are not satisfied with any phase of their operation and are always seeking continuous improvement. They are currently building today what they did in the past with 40% of man hours. OSS believes productivity is the key to future success in global shipbuilding. They have a goal of 6% annual productivity improvement.

Typical build cycle is 12 month with 3 month in the building dock, one month outfitting and 3 weeks deck trials and sea trials. Sea trials are normally 3 days and once the ship leaves the shipyard for sea trials it does not return to shipyard.

OSS does not use the Build Strategy approach, but has a planning system that covers most of the Build Strategy components and recognizes the need to communicate this information in a formal manner to the many users in a shipyard. OSS was not aware of the Build Strategy approach. However, the way they prepare and formally document and distribute their planning documents achieves some of the same objectives. OSS does have a long term business plan and the Phase I part of their planning process is similar to the Shipbuilding Policy. Their planning is totally integrated. OSS has always used standard processes and standard details to the maximum extent. They are an effective part of OSS high productivity in all departments and processes. OSS has very up to date capabilities and is in the fortunate position of having no known limitations for the foreseeable future.

Astilleros Espanoles is a grouping of diverse shipyards covering all sizes of commercial ships and offshore vehicles/rigs. They have a central office in Madrid. This central group performs much of the business planning and setting of each shipyard policy. However, at the meeting with representatives of all shipyards in the group, and at meetings at Sestau and Peurto Real Shipyards, the enthusiasm of individual managers for continuous improvement, including the use of a Build Strategy approach, was very clear.

Each shipyard has its own 5 year plan covering goals, productivity, ship types and employees. A major point in their use of Build Strategy is the development of a catalog of interim products for each shipyard. Build Strategies were reviewed in two shipyards. They covered most of the recommended items in the study proposal Build Strategy Contents List. In addition, they added interesting information about the ship owner, his existing fleet and operations. The study proposed Build Strategy Contents List was modified to incorporate this additional item as an option.

Astilleros Espanoles shipyards cover the range from old shipyards to relatively new facilities, but in all cases they have had significant modernization in the last few years, some of which is still underway. Only one shipyard acknowledged any limitations, and that was the clear width of a bridge through which its ships had to pass to get to the sea.

All of the shipyards visited stated that improvement in productivity was the key to survivability and future success in the global shipbuilding market place.

BUILD STRATEGY DOCUMENT CONTENTS LIST

A contents list, shown in Table III, was developed for the Build Strategy Document from the questionnaire responses, as well as from shipyard visit discussion. The actual Build Strategy Document and the two examples followed this contents list. An introduction outlining the purpose of the Build Strategy Document, its suggested distribution in a shipyard and the prerequisites for a successful Build Strategy was also provided.

TABLE III
PROPOSED BUILD STRATEGY
DOCUMENT CONTENTS

R IS RECOMMENDED
O IS OPTIONAL

1: INTRODUCTION	
1.1 Purpose of Document	R
1.2 Build Strategy Document Prerequisites	R
1.3 Distribution	R
1.4 Summary	R
2: VESSEL DESCRIPTION	
2.1 General Description & Mission	R
2.2 Principal Particulars	R
2.3 Special Characteristics & Requirements	R
2.4 Comparisons/Differences From Previous Vessels	R
2.5 Applicable Regulations & Classification	O
2.6 Owner Particulars	
2.6.1 Background	O
2.6.2 Fleet	O
2.6.3 Past Relationship	O
2.6.4 Competition	O
3: CONTRACTUAL	
3.1 Contractual Dates & Time Constraints	R
3.2 Payment	O
3.3 Liquidated Damages & Penalties	R
3.4 Cancellation	O
3.5 Drawing Approval	O
3.6 Construction Inspection	O
3.7 Trials	O
3.8 Quality	R
4: DESIGN & ENGINEERING	
4.1 Strategy & Scope	
4.1.1 General	R
4.1.2 Changes to Ship Definition Strategy	R
4.1.3Modeling & Composites	R
4.2 Key Drawings	R
4.3 Production Information requirements	
4.3.1 CAM Information	R
4.3.2 Manufacturing Information	R
4.3.3 Parts Listings	R
4.3.4 Installation Drawings	R
4.3.5 Installation Procedures	R
4.4 Design & Engineering Schedule	
4.4.1 Schedule	R
4.4.2 Resourcing & Utilization	O
4.4.3 VFI Schedule	R
4.5 Datum's & Molded Definition	O
4.6 Design Standards	R
4.7 Functional Space Allocations	R
4.8 Detail Design Guidelines	
4.8.1 Steelwork	O
4.8.2 Machinery	O
4.8.3 Pipework	O
4.8.4 Electrical	O
4.8.5 Joinerwork	O
4.8.6 Paintwork	O
5: PROCUREMENT	
5.1 Master Material List	O
5.2 Master Equipment List	O
5.3 Material Procurement Strategy	O
5.4 Procurement Schedule	R
5.5 Critical/Long Lead Items	R
6: PLANNING & PRODUCTION	
6.1 Strategic Planning	
6.1.1 Key Event Program	R
6.1.2 Resourcing & Utilization	O
6.1.3 Changes to Shipbuilding Policy	R
6.1.4 Required Facility, Tooling & Equipment Upgrade	R
6.2 Work Breakdown	
6.2.1 Work Breakdown Structure	R
6.2.2 Coding	R
6.3 List of Planning Unit	
6.3.1 Hull Blocks	R
6.3.2 Zones	R
6.3.3 Equipment Units	R
6.3.4 Systems	R
6.4 Master Schedules	
6.4.1 Hull Blocks	R
6.4.2 Zones	R
6.4.3 Equipment Units	R
6.4.4 Systems	R

6.5 Hull Production Strategy	
6.5.1 Preliminary Process Analysis	O
Integration of Outfit	
Process Analysis By Block	
6.5.2 Non Standard Interim Products	O
6.5.3 Build Location & Launch Condition	R
6.5.4 Erection Schedule	R
6.6 Machinery Space Outfit Strategy	
6.6.1 Equipment Units	R
6.6.2 On Block Outfitting	R
6.6.3 On Board Outfitting	R
6.7 Accommodation Outfit Strategy	R
6.8 Cargo & Other Space Outfit Strategy	
6.8.1 On Block Outfitting	R
6.8.2 On Board Outfitting	R
6.9 Painting Strategy	
6.9.1 Outline Paint Specification	O
6.9.2 Pre-Painting	R
6.9.3 Primer Repair Strategy	R
6.9.4 Unit/Block Painting Strategy	R
6.9.5 Zone Painting Strategy	R
6.9.5.1 Machinery Spaces	
6.9.5.2 Outside Shell and Decks	
6.9.6 Special Considerations	R
6.10 Sub-Contract Requirements	
6.10.1 Bought-In Items	R
6.10.2 Use of On-Site Sub-Contractors	R
6.11 Productivity	
6.11.1 Productivity Targets	R
6.11.2 Comparisons/Differences From Previous Vessels	R
6.12 Temporary Services	
6.12.1 Staging Plan	R
6.12.2 Access & Escape Plan	O
6.12.3 Power & Lighting	O
6.12.4 Weather Protection	O
7: ACCURACY CONTROL MANAGEMENT PLAN	
7.1 System Critical Dimensions & Tolerances	R
7.2 Interim Product Critical Dimensions & Tolerances	R
7.3 Sampling Plan	O
7.4 Special Procedures	O
7.5 Jigs & Fixtures	O

7.6 Hot Work Shrinkage	
7.6.1 Use of Extra Stock	O
7.6.2 Shrinkage Allowances	O
7.6.3 Distortion Control	O
8: TEST & TRIALS	
8.1 Test Planning	
8.1.1 Strategy	R
8.1.2 Schedule (High Level)	R
8.2 Pre-Completion Testing	
8.2.1 Pre-Survey & Dry Survey	O
8.2.2 Pipe Pre-Testing	O
8.2.3 Equipment Unit Pre-Testing	O
8.3 Tank Test Schedule	R
8.4 Equipment Unit Test Schedule	R
8.5 Pipe Unit Test Schedule	R
8.6 Zone Close-Out Strategy	R
8.7 Principal Trials Items	R
9: PERSONNEL	
9.1 Industrial Relations Aspects	
9.1.1 Design	O
9.1.2 Sub-Contract	O
9.2 Training	O
9.3 Project Organization	
9.3.1 Shipyard Organization Charts	R
9.3.2 Client's Organization Charts	R
10: WEIGHT CONTROL	
10.1 General	
10.2 Outline Procedure	R
10.3 Departmental Responsibilities	R

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This paper is based on a report prepared jointly by A&P Appledore International Ltd. and Thomas Lamb, and covers the preparation, distribution and analysis of the responses to the Build Strategy and Shipyard Capabilities and Limitations Questionnaires; a summary of the visits to both U.S. and foreign shipyards; the attempt to develop U.S. shipyard Common Attributes; prerequisites for the use of Build Strategies; the Build Strategy Document and the examples of its use.

Both questionnaires were jointly developed by A& P Appledore International Ltd and Thomas Lamb. However, without the participation of the shipyards who took the time to respond to the questionnaires and those that agreed to allow the project team to visit and discuss the subject further, this report would have no value. Their contributions are acknowledged with appreciation.

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